# Biological Evaluation of Gypsy Moth Populations

# at Tionesta Lake, 2012

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## ABSTRACT

In the fall of 2012, personnel from USDA Forest Service, Northeastern Area, Forest Health Protection, Morgantown Field Office and United States Army Corps of Engineers conducted gypsy moth egg mass surveys on the Tionesta Lake and Dam Project. The purpose of these surveys was to estimate gypsy moth population densities through fall egg mass counts, and to assess the need for treatment in 2013. Predicted populations densities and defoliation levels were estimated to be sufficient to cause moderate to light defoliation on 263 acres in 2013. Treatment to prevent defoliation is recommended in those areas where the predicted level of defoliation has the potential to cause a defoliation and nuisance larval densities, all of which can conflict with existing resource management objectives.

### Purpose and Need

The Morgantown Field Office (MFO) received a request from Jason Quinn, Resource Specialist with the United States Army Corps of Engineers (COE), whose staff were concerned about gypsy moth, *Lymantria dispar* (L.) (Lepidoptera: Lymantriidae) populations at the Tionesta Lake and Dam Project. This evaluation was undertaken by the MFO to address this request and assess what management options were available to protect and maintain the forest resources at Tionesta Lake and Dam.

### Project Location/Description

Tionesta Lake and Dam is located in northwestern Pennsylvania in Forest County (41º28'N, -79º25'W). The project covers approximately 3,100 acres (figure 1). The project was authorized by an Act of Congress in 1938 as part of a flood damage reduction project in the Pittsburgh District. This project is part of a flood control system for the Allegheny and upper Ohio River system.

Tionesta Lake and Dam lies within the hemlock-white pine-northern hardwood region (Braun, 1950). The hemlock-northern hardwood forest type of pre-settlement times was composed mainly of eastern hemlock (*Tsuga canadensis*) and American beech (*Fagus grandifolia*), and it has been replaced by the current mixed upland hardwoods and cherry-maple (Allegheny hardwood) types (Morin et al., 2006; Whitney, 1990).

Tionesta Lake and Dam contains over 200 campsites on 125 developed and undeveloped campgrounds. In addition the project has two boat launches, two canoe access sites and 30 miles, of mountain biking, equestrian and hiking trails.

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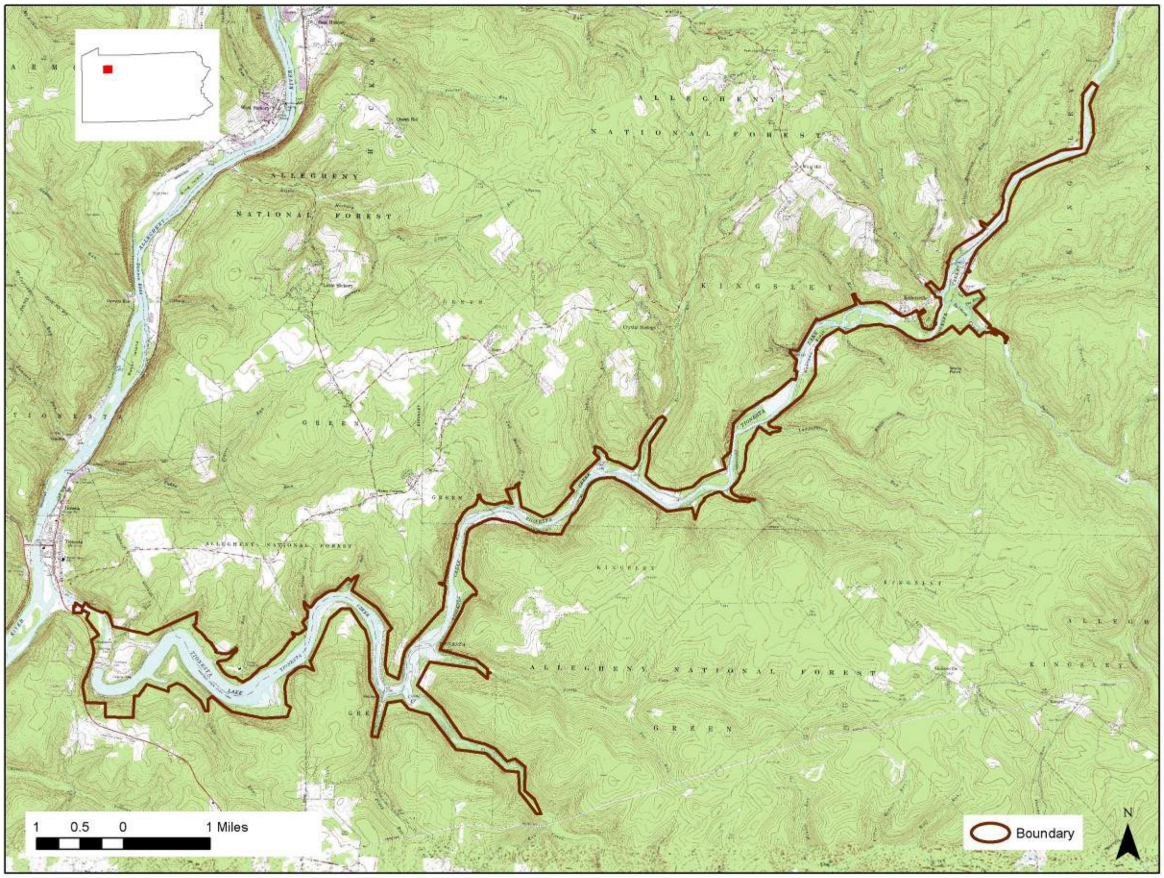


**Figure 1.** Tionesta Lake and Dam in Northwestern Pennsylvania

*Previous projects*

The MFO has had a long relationship with the Tionesta Lake and Dam Project, in 1985 and 1992 this office worked with staff from the project and aerial sprayed 130 and 169 acres respective for gypsy moth control using the microbial insecticide, *Bacillus thuringiensis* variety *kurstaki (B.t.k)*.

## Project Objectives

The objectives of this biological evaluation were to: 1) accurately assess current gypsy moth population densities within susceptible forest types on the Tionesta Lake and Dam Project; 2) determine the likelihood of unacceptable impacts on forest resources occurring in the next growing season; 3) develop treatment alternatives and recommendations to suppress gypsy moth outbreaks likely to cause unacceptable impacts.

## Project Methods

The guidelines used to evaluate the risk of defoliation include: 1) current defoliation level as defined by surveys; 2) previous defoliation events; 3) number of egg masses/acre; 4) size and condition of the egg masses; 5) presence of disease and parasites; 6) availability of preferred food (mainly oaks); 7) risk of larval blow-in following egg hatch.

*ARCMAP data*

We used ARCMAP® data provide by U.S. Army Corps of Engineers for the boundary and worked with Project staff to digitize and break the area into blocks based on use (e.g. campgrounds, recreation areas, and general forest; figure 2). These boundary areas were then overlaid with National Agricultural Imagery Program (NAIP) data and Google earth imagery which was used to digitize tree cover, calculate acreage, define survey blocks (spray blocks) and select survey points.

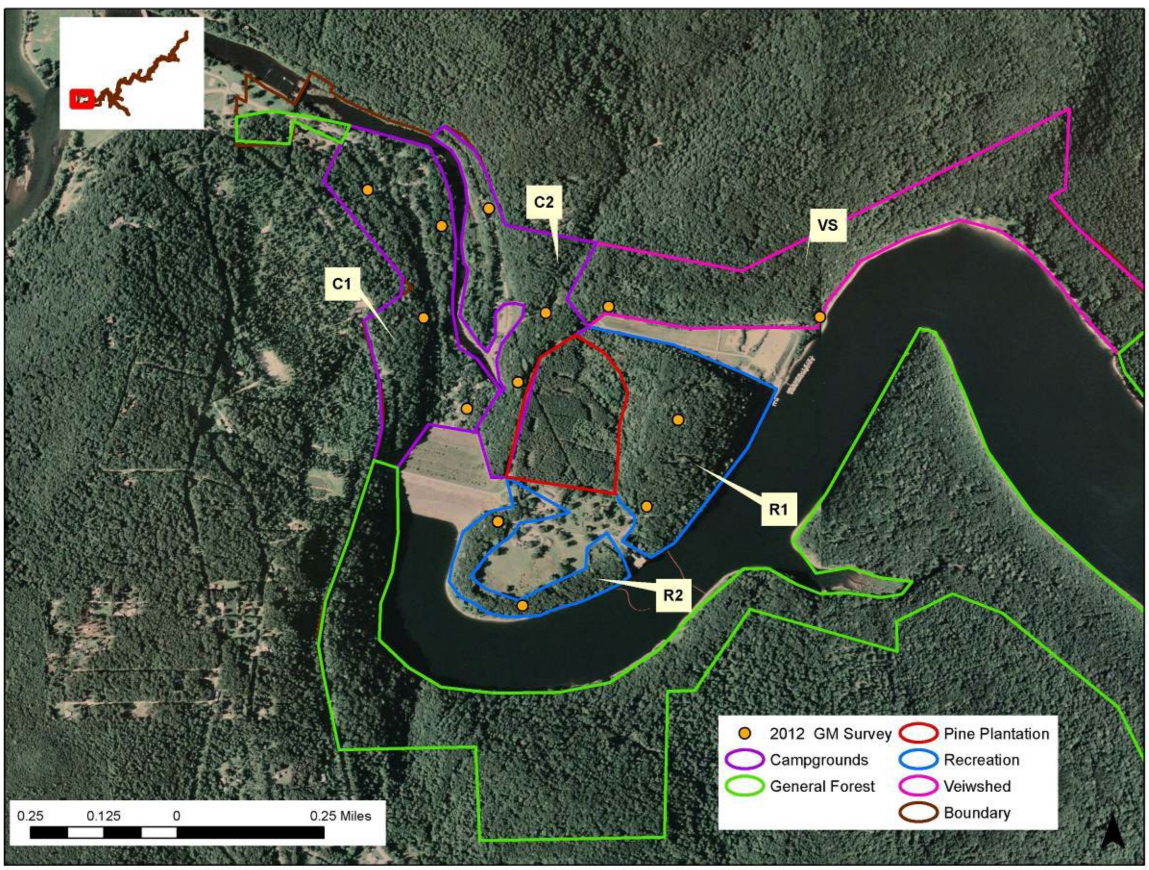


**Figure 2.** Survey sites, and blocks around Tionesta Lake and Dam.

*Survey data*

The number of survey plots, and requirements for qualifying areas (e.g. species composition, treatment block size, percent cover) was based on the Pennsylvania Division of Forest Pest Management Cooperative Forest Insect Pest Suppression Program Manual standards. Surveys plots and were evenly distributed throughout each of the survey blocks. A minimum of two sample points were established within each block with additional survey plots being chosen based on block acreage (Table 1.).

**Table 1.** Number of survey points based on block size.

| BLOCK SIZE (ACRES) | NUMBER OF PLOTS |
|---|---|
| 6-25 | 2 |
| 26-50 | 3 |
| 51-100 | 4 |
| 101-200 | 6 |
| Over 200 acres, add one plot for each 100 acres | |

One-fortieth-acre circular plots (18.6-ft radius) were used to estimate egg mass densities within areas. At each sample point, a 1/40$^{th}$ acre fixed radius plot was established and the percent species composition and number of new and old egg masses were determined by inspection and visual count. An inspection of all egg masses within reach helped estimate the portion of new to old egg masses at each plot. Egg masses visual counts consisted of a tally of all egg masses observed on the overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was summed and multiplied by the ratio of new egg masses to old egg masses (Liebhold et al. 1993) and multiplied by 40 to calculate the number of egg masses per acre. This was repeated for each plot and the results summed and averaged for a single density value for the unit. In addition to density the standard error of the egg mass estimate was also determined to evaluate how much confidence could be placed on the estimate. Three egg masses at each plot were also measured and average to provide additional information on condition and trend of the gypsy moth populations. Small egg masses (i.e. < 20 mm in length) are indicative of a declining population, while large egg masses (i.e. > 30 mm in length) of an increasing population (Liebhold et al. 1994).

*Defoliation predictions*

Defoliation predictions for 2013 within each block were based on egg mass density, threshold, egg mass length, population trends and species composition (Liebhold et al. 1994, Liebhold et al. 1993; Table 2). Intervention thresholds for each area were established based on resource management objectives provided by the Project and included nuisance abatement, and the prevention of defoliation.

**Table 2.** Egg mass density thresholds for resource management objectives.

| Threshold (egg masses/acres) | Predicted Defoliation | Objectives |
|---|---|---|
| 250 | < 30[1] % | Nuisance Abatement |
| 251-500 | 30 - 40 % (Light) | Prevent Noticeable Defoliation |
| 501-1000 | 41 - 60 % (Moderate) | Prevent Growth Loss |
| >1000 | > 60 % (Heavy) | Prevent Mortality |

[1] None or background level of defoliation.

**Results**

The five survey areas covering 263 acres are shown in figures 2 and the gypsy moth population densities in each area are summarized in Table 4. Species composition was a mix of preferred and less preferred species consisting of northern red oak (*Quercus rubra*), white oak (*Q. alba*), Chestnut oak (*Q.prinus*), red maple (*Acer rubrum*), black cherry (*Prunus serotina)*, black birch (*Betula lenta*), yellow birch (*B. alleghaniensis*), American hornbeam (*Carpinus caroliniana*), yellow popular (*Liriodendron tulipifera*) and eastern hemlock (*Tsuga canadensis*). Overall, average egg mass densities ranged from 0-1,260 egg masses/acre. Egg mass lengths tended to be large in size, ranging from 27-50 mm and an average of 37 mm. Gypsy moth population trends (density and egg mass length) in nearly every area are increasing (Table 4). Three of the survey areas, campground area one and two and recreation area two (Table 4) contain egg mass densities sufficient to predict light defoliation (> 35%). The other two areas have egg mass densities sufficient to predict nuisance levels of gypsy moth.

**Table 3.** Blocked area types and acreage based on site visit.

| Block Type | Acres |
|---|---|
| Pine Plantation | 25 |
| Recreation (R1 & R2) | 59 |
| Campgrounds (C1 & C2) | 124 |
| View-shed | 80 |
| General Forest | 1,962 |

**Discussion**

Tionesta Dam personnel observed gypsy moth egg masses and only light defoliation in 2012. Survey results indicate that light to moderate defoliation is likely in the two campgrounds and recreation areas. The potential for “moderate” defoliation in 2013 exists within campground area one where the egg mass counts are between 500–1,000 egg masses/acre. Defoliation at this level creates nuisance larval densities and moderate defoliation that can adversely affect tree growth and have an impact on recreation and view-sheds. The remaining survey areas have egg mass counts of 500 egg masses/acre or less and are likely to have “light” or noticeable levels of

defoliation levels with little impact on growth loss, but nuisance larval densities should be expected.

Predicting the extent of impact of gypsy moth on individual trees or areas is uncertain. In cases in which two or more consecutive years of defoliation have occurred some level of prediction can be made based on changes in egg mass density, size, and presence of control factors (i.e. predators, parasites and diseases). Gypsy moth population trends (density and egg mass length) in every area are increasing (Table 4). Field observations by Tionesta staff revealed that few if

**Table 4.** Gypsy moth egg mass survey results, thresholds and predicted defoliation for the Tionesta Dam site.

| Area | 2012 | | 2011 | | Egg Mass Threshold | 2013 Defoliation Prediction[2] |
|---|---|---|---|---|---|---|
| | Egg Mass Density[1] | Standard Deviation | Egg Mass Density[1] | Standard Deviation | | |
| Campground 1 | 565 | 486 | 35 | 70 | ≤ 250 | 41 % |
| Campground 2 | 293 | 349 | 67 | 115 | ≤ 250 | 36 % |
| Rec Area 1 | 150 | 14 | 0 | 0 | ≤ 250 | < 30 % |
| Rec Area 2 | 470 | 184 | 270 | 99 | ≤ 250 | 37 % |
| View-shed | 130 | 14 | 0 | 0 | 251-500 | < 30 % |

[1]Egg masses/acre; [2] Weibull function (Liebhold et al. 1994); [3]

any trees re-foliated because of gypsy moth defoliation. Since defoliation reduces the trees ability for future photosynthesis and re-foliation events causes the tree to expend carbohydrate reserves during re-foliation it is these factors that must be considered when deciding whether intervention is necessary or warranted. Other factors that need to be considered are the condition of the trees at the time of defoliation (i.e. stand stocking, age and amount of susceptible species present). Studies have shown (Gottschalk 1989), that reduced growth, mast abortion branch dieback or in some cases tree mortality, has been observed following a single year of heavy defoliation. Should a subsequent period of drought or other stressors occur during a defoliation event or even after, the potential impact on individual trees may be is compounded.

Trees that receive light-moderate defoliation (40 to < 60 percent) are not likely to refoliate and expend food resources but are likely to show some level of growth loss (Liebhold et al. 1994). In hardwood forests, about 30 percent of leaves must be eaten for defoliation to become noticeable and levels below this are likely the result of background levels of feeding and damage.

The natural control factors operating in the survey areas were not quantitatively surveyed, but observations indicate that the size of new egg masses was large with an almost constant presence of *Ooencyrtus kuvanae,* (Howard) (Hymenoptera: Encyrtidae) a parasitic wasp specific to gypsy moth eggs. Although not observed during this survey the gypsy moth fungus, *Entomophaga maimaiga* is known to be present wherever gypsy moth is distributed in Pennsylvania. It is

likely this fungus could adversely influence gypsy moth infestations on the Tionesta especially if there is wet spring weather. The gypsy moth nucleopolyhedral virus was also not observed, but this pathogen operates at high larval density and does not kill as quickly as the fungus so its effects are usually masked by the presence of the fungus.

**Management Options**

For 2013, two management options have been evaluated based on decisions by the Tionesta Lake and Dam Project for managing gypsy moth populations. The intervention option is offered based upon the following three treatment objectives: 1) for nuisance abatement of gypsy moth population in high value camping and recreation areas and 2) protect host tree foliage to prevent branch dieback and tree mortality. Each option is discussed below.

*No Action option*

It is possible that gypsy moth populations could collapse due to the presence of the gypsy moth nucleopolyhedrosis virus (NPV) or the gypsy moth fungus, *Entomophaga maimaiga.* Where defoliating gypsy moth populations are greater than 500 egg masses/acre viral epizootics generally manifest themselves only after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in two-three years *once* they reach defoliating levels and then collapse because of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for three-six years before rebuilding to defoliating levels. Although it is difficult to accurately assess the sequence of such events, it is unlikely that a collapse will occur since these areas are in the first or second year of infestation and there is an abundance of large egg masses.

Should this option be selected, it is likely that defoliation will occur and population densities will increase in newly infested stands and expand to currently uninfested areas.

*Microbial insecticide option*

The second option is to use a microbial insecticide to manage gypsy moth populations. The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide, *Bacillus thuringiensis* variety *kurstaki (B.t.k).* *B.t.k.* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis, which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *B.t.k.* has been shown to impact other non-target caterpillars that are exposed to the treatment and are actively feeding. *B.t.k.* is persistent on foliage for about 7-10 days.

*B.t.k* is not target specific and may reduce the populations of non-target organisms either because of direct toxicity or indirectly, by reducing food supplies. Several factors must be taken into account when using *B.t.k* such as: 1) the potential for non-target extirpation in the proposed spray area; 2) the life stage present and any deferential susceptibility to *B.t.k* that may exist between species of non-target organisms; 3) the size and uniqueness of the area beginning proposed for treatment. Since much of this site-specific data regarding non-target organisms may not be known for many areas the potential benefits must be weighed against any potential impacts to non-targets.

*B.t.k.* formulations are available as a flowable concentrate. The normal application rates range from 24-38 billion international units (BIUs) per acre in a single application for a total volume of ½ to ¾ gallon per acre. Double applications may be used in areas of healthy building populations where the egg mass densities may exceed 3,000 egg masses per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely. Because *B.t.k.* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

With the previously described options in mind, the following alternatives are offered.

**Alternatives**

| | |
|---|---|
| Alternative 1. | -No action |
| Alternative 2 | -One aerial application of *B.t.k.* at the rate of 24-38 BIU/acre for all proposed spray areas. |

**Recommendations**

It is recommended that Tionesta Lake decide in favor of alternatives two. Tionesta Lake and Dam resource values, such as recreation, and wildlife would be protected by the suppression of potentially damaging gypsy moth populations where these values are at the greatest risk. This decision would prevent additional unacceptable damage to forest resource values and uses caused by defoliation likely during 2013. For the proposed treatment areas one applications of *B.t.k* would be expected to prevent larval nuisance and light to moderate defoliation that adversely affects recreation view-sheds, values and uses.

**Species Evaluation**

The gypsy moth, *Lymantria dispar* (Linneaus) is a non-native defoliator of forest, shade and ornamental trees throughout the Northeastern United States. Since its intentional importation and accidental release in eastern Massachusetts in 1869, the gypsy moth has steadily expanded its range.

The gypsy moth produces one generation per year. Larvae begin hatching from egg masses in late April and early May when tree buds begin to open. At this time, larvae go through an obligatory dispersal period where they leave the vicinity of the egg, moving upward and spinning a thread of silk as they go (Leonard 1981). Eventually the wind catches the larvae and disperses them. Airborne larvae are carried and deposited some distance downwind from the source with the following results: 1) larvae will land on or crawl onto acceptable host plants and begin feeding; 2) larvae will land on either acceptable or unacceptable host plants and re-disperse; 3) larvae will be deposited into areas unacceptable for survival and re-dispersal where they will die (Mason and McManus 1981). The larvae feed for two to three months completing their development by late June and early July and seek sheltered areas in which to pupate. The pupal period last anywhere from 10 days to two weeks. After emerging from the pupal case the females, which cannot fly, crawl a short distance and emit a pheromone scent to attract males. After mating, the female lays a single egg mass that contains from 75 to 1,000 eggs, which she covers with hairs from her abdomen giving it a fuzzy brown texture and color. The egg masses over winter and hatch the following spring.

The number of host trees and shrubs fed on by the gypsy moth exceeds 300 species, with species of oaks (*Quercus* spp.) ranked among the most favored (Leonard 1981).

**Favored Tree Species** – The following is a listing of common tree species arranged by gypsy moth feeding preference:

- **Favored – High:** Fed upon by all size larvae – alder, apple, aspen, basswood, beech, birches (gray, white, and river), boxelder, hawthorn, larch, oaks (all species), willows, and witchhazel.

- **Favored – Moderate:** Fed upon by only large larvae – chestnut, eastern hemlock, and all species of pine and spruce.

- **Favored – Low:** Only fed upon by large larvae when preferred foliage is not available – birches (black and yellow), butternut, cherry, cottonwood, elms, gum (black), hackberry, hickories, hornbeam, maples, pear, sassafras, sweetgum, and walnut.

- **Unfavored:** Rarely fed upon – ashes (all species), catalpa, dogwood, holly (American), honey locust, horsechestnut, juniper, locust, maple (striped), mulberry, persimmon, red cedar (eastern), sycamore, and tulip poplar.

Gypsy moth is an outbreak species whose populations can remain at low levels for several years, then undergo large population increases in a matter of one or two years. After populations have increased to an outbreak density they can remain high for one to five years, outbreaks decline suddenly to low densities where it is difficult to find any life stage (Liebhold et al. 2000). The main effects of gypsy moth feeding on individual trees involves the depletion of root carbohydrate food resources leading to a reduction in growth, reproduction, and increased vulnerability to secondary agents of mortality. Heavy defoliation forces re-foliation which occurs when about 60 percent of the foliage is lost (Liebhold et al. 1994). This re-foliation uses carbohydrate reserves in trees and can increase their vulnerability to drought and to other insects and diseases. This defoliation and subsequent tree mortality can alter wildlife habitats, change water quality and temperature, increase forest floor temperatures and light levels and reduces aesthetic, recreational, and property values of forests and urban environments.

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